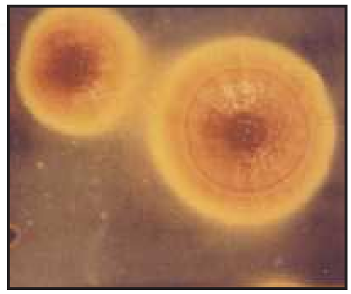
Biohydrometallurgy Research and Development at the Idaho National Engineering and Environmental Laboratory

Introduction

The Biotechnologies Department at the Idaho National Engineering & Environmental Laboratory (INEEL) has had a longstanding multidisciplinary program in biohydrometallurgy. For over a decade, INEEL researchers have supported the U.S. Bureau of Mines (USBM) Strategic and Critical Metals Program, exploring new biological approaches to the extraction and recovery of cobalt and other metals. Prior to the closing of the USBM, the INEEL investigated the microbial ecology of a subsurface chalcopyrite deposit as a component of the Bureau's *in situ* mining program. Independent of USBM-funded projects, the INEEL has developed biological strategies for leaching of arsenopyrite ores (including the use of genetic engineering to improve arsenic resistance in acidophilic bacteria), acid rock drainage mitigation, cyanide degradation in gold mining operations, selenium and chromium reduction, and metal sorption. The INEEL organized and hosted the International Biohydrometallurgy Symposium at Jackson Hole, Wyoming, in both 1989 and 1993. Research continues in support of U.S. and international mining interests in the application of biohydrometallurgy in the mining industry.



Bioleaching of Sulfide Minerals

While bacterial leaching of sulfide minerals has been practiced for centuries, it was in 1947 that Colmer and Hinkle first isolated the chemolithotrophic, acidophilic ("Rock-eating, acid-loving") bacterium, *Thiobacillus ferrooxidans* from an acid drainage source. Over the last 50 years, this microbe has been studied extensively to understand its role in the dissolution of mineral sulfides. However, recent information now suggests that *T. ferrooxidans* is only one of a number of acidophilic bacteria that contribute to the leaching of sulfide minerals, and suggests that control of the biological component of sulfide mineral leaching will require greater understanding of the microbial ecology of acid leaching environments.

The Blackbird Mine in Cobalt, Idaho has been the setting for many leaching studies performed by the INEEL. Other sites include the Champagne Mine (gold oxide) near Arco, Idaho, and a number of copper mines in Utah and Arizona.

In Situ Leaching of Chalcopyrite

As domestic and international high grade copper reserves are depleted, chalcopyrite is emerging as the primary copper resource. Chalcopyrite reserves in the U.S. are commonly found at extreme depths (>1000 ft below land surface), where conventional mining technologies become prohibitively expensive. To exploit future reserves, new strategies must be developed. In collaboration with the USBM and the Cyprus Mineral Park Mine in Arizona, the INEEL examined microbes present in a subsurface chalcopyrite porphury deposit. From this study, bacteria with unique capabilities to extract copper

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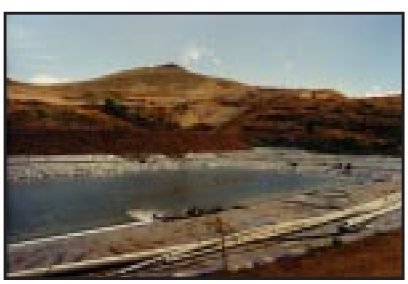
from deep, undisturbed deposits may be identified, and strategies to recover the copper using a biological lixiviant may be developed.

Phosphate Biosolubilization

The importance of microbial solubilization of phosphate was demonstrated 45 years ago. Using a naturally occurring microorganism selected from screening over 800 isolates, a continuous flow bioprocess has been developed at the INEEL that liberates to 97% of the phosphate if O_2 is available in rock phosphate. The objective of this work is to provide an economical, environmentally friendly (green) technology to the phosphate industry. It is estimated that implementation of this innovative "green" technology will dramatically reduce costs associated with phosphate production and associated environmental liabilities.



Cyanide Biodegradation

Cyanide is used extensively in the mining industry, and is often applied directly to ore heaps to recover gold. In order to speed the closure of mines, or to mitigate potential releases, strategies to destroy cyanide applied to heaps must be developed. INEEL scientists, in collaboration with the University of Selma, have characterized a bacterium capable of degrading cyanide to harmless carbon dioxide.

Selenium and Chromium

Through several independent efforts, the INEEL has identified microorganisms capable of reducing selenium and chromium to forms that are readily precipitated from solution. A pilot scale demonstration of chromium reduction using immobilized bacterial cells has been completed for the U.S. Air Force.

Acid Rock Drainage Mitigation

Treatment of acid drainage from sulfide mineral mines is a major cost to mining companies, and an environmental concern to regulatory agencies and the public. The INEEL has developed a passive strategy to precipitate heavy metals and been awarded a patent on a modular bioreactor design, to precipitate heavy metals and raise the pH of acid drainage. The bioreactor and process can be used to remediate other streams that contain metals, sulfates and nitrates, such as agricultural wastewater.

For information contact:

Jerry L. May
e-mail: jlm@inel.gov
Phone: (208) 526-6674

John Alexander
e-mail: jala@inel.gov
Phone: (208) 526-0849